[Proc. Roy. Soc. Victoria, **54** (N.S.), Pt. II., 1942.]

Art. XIII.—*The Bearing of the Tertiary Sub-Basaltic Deposits on the Palaeogeography of the Lilydale District.*

By EDMUND D. GILL, B.A., B.D.

[Read 11th December, 1941; issued separately, 31st August, 1942.]

Contents.

Introduction.
Extent and Character of the Deposits.
Palaeogeography.
Relation to Alleged Faulting.
Summary and Conclusions.
Acknowledgments.

Introduction.

Selwyn (1856) and Murray (1887) made early references to the Older Basalt and accompanying deposits at Lilydale, the latter believing them to be connected with an ancient river flowing from Hoddle's Creek through Lilydale and Kangaroo Ground to Melbourne. Cresswell (1893), Stirling (1899), Morris (1914), and Keble (1918) have also commented on these deposits and references to their views have been made under appropriate sections.

Extent and Character of the Deposits.

The deposits now to be described are to be found in the parishes of Mooroolbark, Lilydale, and Gruyere. The Older Basalt of this area consists of highly decomposed residuals capping the hills. The largest residual is that at Lilydale, which is $2\frac{1}{2}$ miles long and from $\frac{3}{4}$ mile to $1\frac{1}{2}$ miles wide. The sub-Older-Basalt deposits are fluviatile in origin and consist of clays, sands, quartzites, conglomerates, gravels, and ferruginous grits. The sands and quartzites are known to be fossiliferous.

Clays.

At Melbourne Hill, Lilydale (locality 2 on map, Gill 1940, p. 252), a bed of clay outcrops in the road cutting under the basalt and unconformably over the bedrock of Yeringian strata. Similar clay is seen on Edward Road where the northern boundary of the basalt residual crosses that thoroughfare, and at Cave Hill. Cresswell (1893) shows (fig. 10) "Whitish clay" between the limestone and the basalt in the railway cutting just south of Cave Hill. Stirling (1899) refers to it as "basaltic clay."

Sands.

Current bedded sands can be seen outcropping in the paddock at Black Springs on the north-eastern corner of the junction of the Lilydale Highway and Edward Road where they rest unconformably on fossiliferous Yeringian sandstones and mudstones. This is the locality from which Mr. W. H. Ferguson collected fossil leaves, to which he has referred as "Laurel leaves" (Ferguson, 1931, p. 52). Dr. R. T. Patton has kindly examined these leaves, and determined them as *Nothofagus* sp. Sub-basaltic river sands also occur at Melbourne Hill, Lilydale, and in the railway cutting immediately south of Cave Hill (22 miles 9½ chains to 22 miles 12 chains). The largest of the extant deposits is at Cave Hill where they have been revealed by quarrying operations. Specimens have been collected which show the gradation from sand into the accompanying quartzite, which was formerly thought to be of Palaeozoic age. Silicified wood (M.U.G.D. Fossil Coll., reg. no. 1737) from the Cave Hill sands has been sectioned at the Geology Department of the University by Mr. G. Baker, and determined by Miss A. M. Eckersley as referable to the family Lauraceae, probably the genus *Beilschmiedia.*

An interesting feature of the Cave Hill sands is their inclusion of sheared and crushed pebbles. Such have not been found in any of the other sub-basaltic deposits of the district. As they are embedded in sands, their crushing can only have occurred *in situ* if they were formerly cemented and have since been decemented. They may have been derived from a crush zone elsewhere but the displaced edges do not show wear due to transport by water. The pebbles are of whitish, very hard quartzite.

Sands occurring in the parish of Gruyere will be described in a subsequent section.

Quartzites.

These occur mainly in the parish of Mooroolbark, and consist chiefly of ridges of meridional trend running from Cave Hill towards Mooroolbark itself. On the eastern side of Cave Hill the quartzite appears to extend over the toscanite which is the lowest member of the Dandenong Mountains igneous suite. This extension is not unlikely since there is an outlier of toscanite north of Cave Hill and half a mile north-west of Lilydale railway station. The Olinda Creek alluvium in this area probably rests on a bedrock of toscanite. East of Cave Hill the toscanite actually outcrops in the bed of Olinda Creek.

Cresswell (1893) drew a geological section through Cave Hill, and stated that the quartzites and conglomerates are Upper Silurian (= present Silurian) in age, and are conformable with the limestones of Cave Hill. Morris (1914) referred the sands to the Tertiary period, but considered the quartzites and conglomerates to be Palaeozoic in age. The possession by the quartzite ridges of a strike similar to that of the Palaeozoic bed-rock has lent colour to this interpretation. Their elevation above that of the surrounding Palaeozoic strata was explained as being due to the more resistant character of the quartzitic beds. Some 10 years ago Mr. W. H. Ferguson mapped the area (Geol. Surv. Vic. unpublished map) and indicated the age of the quartzites and associated deposits as "Lower Tertiary." The excavation of the limestone at Cave Hill quarry in recent years has clearly exposed the unconformity between the limestone and the overlying sands-quartzite association. A horizontal bore at right angles to the strike in the eastern wall of the quarry has proved the extension of the limestone for 276 feet. Moreover, the discovery of the fossil wood in sands under the quartzite proves the Tertiary age. Furthermore, on the north side of Cave Hill there have been collected numerous pieces of quartzite containing holes which are possibly the casts of sticks and twigs. Quartzite also occurs with the sands in the railway cutting south of Cave Hill (22 mls. 11 chains). It also occurs in the parish of Gruyere as will be mentioned subsequently.

Conglomerates.

To the south of Cave Hill there are conglomeratic beds which have been silicified to varying degrees. Large pebbles occur in a matrix consisting of cemented quartz sand and gravel, and they consist chiefly of quartz and quartzose sandstone. In the parish of Gruyere small local occurrences of pebbly gravels grading into conglomerates are found.

Gravels.

Deposits of uncompacted water-worn fragments which are larger in size than those of the sands may be described as gravels. On the northern boundary of section 21, parish of Yering (Military map grid reference 340,470 Ringwood Sheet) there is a small residual of Older Basalt, and on its southern side quartz pebbles are common in the cultivated ground, indicative of a deposit of sub-basaltic gravel. There is a deposit of gravel north-east from this point, across Edward Road, also on top of a high hill, and this is regarded as being the eastern extension of the same sub-basaltic accumulation. The gravel is 15 to 20 feet thick and contains pebbles up to 10 inches in diameter.

At the upstream end of Yering Gorge there is a deposit of gravel some four to five feet thick, about 30 feet above the present River Yarra level. The deposit is aligned parallel to the river course and was evidently deposited by that stream. Ferguson mapped this and a less conspicuous patch at about the same height at the other end of the Gorge with the other "Lower Tertiary" rocks. These gravels are between 100 and 150 feet lower than the undoubted sub-basaltic deposits. However, no similar deposits of gravel by the Yarra are to be seen anywhere in the

Hill road, a small outcrop of granodiorite porphyrite (G. Baker determination: M.U.G.D. Slide Coll. No. 5185) about 15 feet in diameter and about a foot high was blasted from a small ridge running east and west. The rock was outcropping through the Older Basalt and was removed to facilitate cultivation. This rock, which is rich in quartz, may be one of the sources for the quartzose materials of the sub-basaltic deposits.

Palaeogeography.

The extent and thickness of the sub-Older-Basaltic deposits of the Lilydale District appear to the writer to be incongruous with the view that they belonged to a stream originating a few miles away on the Kinglake Plateau. The quartzite ridges rise 50 feet and sometimes more above the bedrock. At Cave Hill up to 30 feet of sands can be seen in the quarry face surmounted by some 10 feet of quartzite. Also the deposits are laterally widespread, extending $1\frac{1}{2}$ miles even in extant formations. Furthermore, the material must have been transported for some distance because there are no sources nearby from which there could possibly originate so great an amount of quartzose materials. What remains now must be only a fraction of the original deposits. It is thus clear that a river of some magnitude must have flowed over this area, but its course as explained by Keble (1918, p. 158) is inadequate to explain the occurrences. Keble considered that a river, commencing on the Kinglake Plateau, flowed alongside the Wurunjerri Range, followed a course parallel to the present Steel's Creek, then proceeded southwards through Lilydale to the sea, probably near Frankston. He regarded the high ground east of Steel's Creek as an uncovered residual which represented the course of the pre-basaltic stream. This area, however, consists of very steep country which constitutes the erosional escarpment of the Kinglake Plateau. A prominent hill called " The Pinacles," 912 feet high, is situated there, and in two miles southwards the elevation drops to 300 feet. The Steel's Creek area cannot be considered as part of the course of the pre-basaltic stream.

The relative levels of the sub-basaltic deposits show that the pre-basaltic river flowed southwards through Lilydale, so if the upstream part of this ancient river did not come from the north (Kinglake Plateau), it must have come from the west or the east. It did not come from the west because along that flank ran the Wurunjerri Range (Keble, 1918; Hills, 1934). It must therefore have come from the east. However, to the immediate east is the Dandenong Range, terminating to the north in a long tongue of toscanite which extends as far as Coldstream. The River Yarra has reduced the country to the north of the toscanite below the level of the pre-basaltic terrain, so no trace of the ancient river can be found there, but immediately to the east of the toscanite flow, in the parish of Gruyere, big deposits of sub-basaltic materials are found. The character and extent of these are comparable with those of Lilydale, and show that this is the main course of the pre-basaltic river. Probably the reason which caused physiographers to look to the north for the continuation of the sub-basaltic river is that it was believed that the Woori Yallock basin was drained by a river which flowed southwards through the Gembrook Gap (Gregory, 1903; Keble, 1918). Edwards (1940) has recently shown that the pre-basaltic terrain in this area had a northerly and not a southerly slope. The evidence brought forward by Edwards (and now extended) of a basin with a northerly slope is so clear and definite that an indecisive ecological argument as developed by Clark (1941) based on the distribution of *Euastacus* cannot discount it.

Mr. G. Baker, M.Sc., kindly made a heavy mineral analysis of a sample of sub-basaltic gravel collected from the location of the mine shafts south of the Warburton railway line near Burgi's Hill. Mr. Baker's report, which throws light on the origin of the sub-basaltic materials, is as follows:

"Macro: Grain size ranges from very fine clay to pebbles of quartz up to 10 mm. diameter and sandstone up to 32 mm. Quartz translucent, and mainly granitic. A few grains of reef quartz present. Grains principally angular. Bleached biotite present in fairly large flakes. Occasional small pebbles of limonite were observed; also a few felspar grains and some of kaolin.

Micro: Heavy minerals obtained by sieving and using material 0·5 mm. and under, washed free of fine clay, then separated in bromoform (S.G. 2·88). The proportion of heavy minerals to others is small. The minerals present are—

Ilmenite—abundant in heavy mineral residuum.
Biotite—brown and bleached.
Tourmaline—rare angular fragments and prisms, one rounded (waterworn).
Zircon—rare. Yellow and colourless crystals; some acicular, some showing 'torpedo' habit, one zoned, few water-clear, some showing normal prism and pyramid faces; a few contain inclusions. One waterworn.
Rutile—rare prisms.
Cassiterite—rare grains.
Anatase—one crystal (blue variety).
Brookite—one crystal.
Staurolite—one or two grains.
Topaz—rare grains.
Limonite and Leucoxene—occasional pseudomorphs after ilmenite.

Note.—The presence of fresh biotite, the angularity of most grains, the occurrence of well-preserved crystal forms in zircon, rutile, and some of the tourmaline, and the abundance of ilmenite, indicate derivation from a nearby acidic igneous mass and contact zone."

This report deals with material which lies to a thickness of 30 feet or more over the intrusion reported earlier in this paper. The origin of the material must be sought upstream from this point. If the pre-basaltic stream flowed southwards, then it is impossible to find an adequate source for the great quantity of sub-basaltic materials. On the other hand, if the stream flowed northwards in this area, an adequate source for the material can be found in the granitoid rocks and dacites bordering on the Woori Yallock basin. A further piece of corroborative evidence is seen in the fact that the Older Basalt of the residuals at Silvan (in the Woori Yallock basin) and at Lilydale are both of the Flinders type (Edwards, 1939), whereas that at Berwick (south of the Gembrook gap) is different.

That the pre-basaltic river flowed in a mature valley is shown by the wide lateral extent of the fluviatile deposits, and secondly by the gradient of the stream as shown by the elevations of the bases of the lava residuals. At Lilydale the fluviatile deposits extend for the full width of the lava residual, viz. $1\frac{1}{2}$ miles, and may originally have been wider. At the south border of the parish of Gruyere, the base of the older basalt is between 550 and 600 feet above sea-level, while west of Coldstream (Edward Rd.) it is approximately 450 feet, and at Lilydale it is about 400 feet. These figures indicate a gradient in the region of 15 feet fall per mile, which is approximately the devexity of the Dandenong Creek.

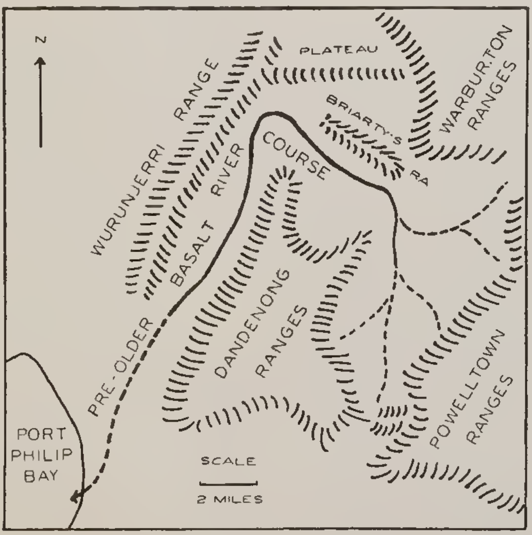

FIG. 2.—The Course of the Pre-Basaltic River. (The broken line shows the probable course where the precise one is not known.)

The general picture of the pre-basaltic stream is thus of a large river which drained the Woori Yallock basin, with tributaries which derived detritus from the Powelltown and Dandenong Ranges (fig. 2). This river did not flow east of the Warramate Hills as does the present River Yarra, but west of them, between that range and the toscanite hills further west. In

Oligocene times, which is probably the age of the basalt, the Warramate Hills were very likely continuous with the prominent V-shaped ridge to the north-west of them, for even now there are quite prominent hills in between them which have no Older-Basaltic deposits on them. The V-shaped ridge is caused by the southerly pitch of a highly siliceous Yeringian horizon folded in a syncline, as surmized by Morris (1914). Its continuation to the south is seen in the prominent ridge which runs parallel with Boundary Road. The pre-basaltic river flowed to the north-west between the eminences just mentioned and the toscanite mass (fig. 1). The river quite probably continued in that direction until it met the Wurunjerri Range between Yarra Glen and Yering Gorge, whereupon it was deflected southwards between that Range and the Dandenong mountains, thus passing through Lilydale. The levels of the Older Basalt and associated deposits in the parish of Gruyere show that the Warramate Hills are not an " uncovered residual " (Keble, 1918), but a ridge of Palaeozoic sediments owing their prominence to their greatest hardness, i.e., to differential erosion (Hills, 1934; Edwards, 1940).

Relation to Alleged Faulting.

Another inference from the palaeogeography is that there has been no major faulting in the vicinity of Lilydale in Tertiary times. This has a bearing on the Senkungsfeld Theory of Jutson (1911), and the problem of the Yering Gorge. Jutson considered a fault to be present along Brushy Creek because of the presence of a well-defined scarp to the west and a lowland to the east which he termed the "Croydon Senkungsfeld." Hills (1934) explained this by differential erosion because of the presence of hard quartzitic sandstones on the scarp, and because the supposed fault closely followed the strike of the beds. This contention is supported by the study of the pre-basaltic terrain, and also by a survey of the lithological types present in the area. The alleged differential throw of the fault corresponds to the hardness of the rocks at the points given. Jutson wrote, " The difference in height at the various points (e.g., at the mouth of Brushy Creek, about 200 feet, at Croydon about 140 feet, and at the " Kopje " about 85 feet), between the Yarra Plateau and the Croydon Senkungsfeld, indicates approximately the throw of the Brushy Creek fault." At the mouth of Brushy Creek is a very hard dyke of quartz porphyry, at Croydon there are resistant quartzitic sandstones, and at the " Kopje " micaceous sandstones of a less resistant character. At the northern end of the " Senkungsfeld " Jutson made the Brushy Creek fault swing away to the east of north and pass along the margin of Yering Gorge, where he claimed that the Yarra is antecedent to the fault. Jutson's section of Yering Gorge (1911, Plate LXXXVI.) shows both sides of the Gorge of equal height, but the section as drawn from the contours of the Military Map (which was not available to Jutson) appears as in fig. 3.

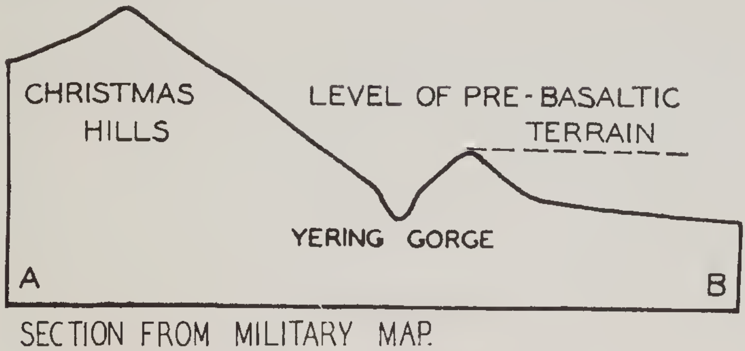

Fig. 3.—Section on Line A–B in Fig. 1 across Yering Gorge. Horizontal Scale: 2 in. = 1 mile; Vertical Scale: 1 in. = 1/10th mile.

The hill on the east side of the river is approximately the same height as most of the hills between Yering Gorge and Lilydale. The prominent ridge running from the basalt residual at Lilydale to the gorge is an "uncovered residual." At its northern end it has a small residual of basalt and deposits of gravel. It has no relation to the strike or hardness of the country rock and owes its elevation to its protection, until recently, by a capping of basalt. These hilltops, therefore, represent the level of the pre-basaltic terrain, whereas the high country to the west of the Gorge (the Christmas Hills) is really a spur of the Kinglake Plateau. The author is of the opinion that the Yering Gorge is due to the formation of a marginal stream where the Older Basalt was contiguous with the Wurunjerri Range. The stream was able to incise the bedrock more easily than the basalt, and so it cut down into the rocks which are hard compared with other Palaeozoic strata now exposed. The Yarra at this point is therefore a "superimposed" stream. When once the less resistant adjoining strata were uncovered by the removal of the basalt, they were more quickly reduced by the sub-aerial forces, and so there is a low saddle (262 feet above sea level) to the east of the Gorge. This is approached on both sides by embayments in the river valley, and in a short time (geologically) the remaining wall of rock, which is only about 25 feet above river level, will be reduced, and the river will short-cut across this point, leaving a wind-gap where the Gorge now is.

The views set out in this paper also suggest an origin for the Yarra flats different from that given by Hills (1934, 1935), viz., that the eruption of a volcano at Lilydale blocked the pre-basaltic river and caused it to overflow across a saddle in the Wurunjerri Range. Chapman (1909) was apparently the first to suggest that the depressions on the hill west of Lilydale are volcanic vents. Morris (1914) supported the idea, but did so with reserve (p. 361). Hills adopted the idea to explain the deflection of the Yarra, but does not now himself adhere to that view (personal communication). Even if "Crater Hill" (as some residents call it) were a point of eruption, we cannot expect that well-shaped craters would persist since ? Oligocene times. The rock in this area is thoroughly decomposed, but occasional small pebbles of basalt are found in the red soil. Basalt is quarried for road purposes a little lower down the hill. There is no evidence of the presence of any fragmental volcanic rocks. The Yarra flats probably owe their origin to the formation of a local base-level by the Yarra because of its restriction at Yering Gorge between the quartzitic sandstones and the basalt. It is imagined that after the basalt flow had filled the valley of the pre-basaltic river, that a stream developed marginal to the flow, following the edge of the Kinglake Plateau in the north and continuing southwards along the edge of the Wurunjerri Range. The rocks on the edge of the erosion escarpment of the plateau in the vicinity of where Yarra Glen and Tarrawarra now stand would be more readily eroded than the resistant quartzitic rocks of the Wurunjerri Range. Thus the river upstream from the Gorge would tend to oscillate from side to side, widening its valley and in time becoming an aggrading stream (Hills, 1934, p. 169). There may have been other factors operating, but the formation of the flats has probably been due chiefly to the above cause. A similar local base-level, but on a smaller scale, has been formed between Yering Gorge and the Warrandyte Gorge.

Summary and Conclusions.

Fluviatile deposits of clays, sands, quartzites, gravels, conglomerates, and grits have been described from the parishes of Mooroolbark, Lilydale, and Gruyere. Fossil leaves and wood are named.

The aggregations indicate by their lateral extent, their depth, and their elevations above sea-level that a large river flowed there in a mature valley.

This river drained the Woori Yallock basin northwards, then flanking the toscanite mass at Coldstream, turned southwards through Lilydale. The river did not originate on the Kinglake Plateau as formerly thought.

The reconstruction of the pre-basaltic terrain shows that there has been no major faulting in the vicinity of Lilydale. This means, among other things, that some other explanation than that previously given is required to explain the Yering Gorge. A theory of its origin is advanced. The origin of the Yarra flats is also discussed.

Acknowledgments.

Facilities for study have been made available at the University Geology Department, and for this I am obliged to Professor H. S. Summers. It has been my advantage to discuss the significance of lava residuals with Mr. R. A. Keble, the author of a well-known paper on that subject (Keble, 1918). I am indebted to Mr. G. Baker, M.Sc., for making a heavy mineral analysis of a sample of gravel and for cutting the sections of fossil wood. The Director of the Geological Survey, Mr. W. Baragwanath, favoured me with a copy of Mr. Ferguson's unpublished map. I am indebted also to Dr. F. A. Singleton for reading over the manuscript.

References.

CHAPMAN, F., 1909.—Excursion to Lilydale. *Vic. Nat.*, vol. xxvi., May, pp. 7-8.

CLARK, ELLEN, 1941.—Revision of the Genus *Euastacus* (Crayfishes, Family Parastacidae), with Notes on the Distribution of Certain Species. *Mem. Nat. Mus. Vic.*, 12, pp. 7-30.

CRESSWELL, A. W., 1893.—Notes on the Lilydale Limestone. *Proc. Roy. Soc. Vic.*, n.s., 5, pp. 38-44.

EDWARDS, A. B., 1939.—Petrology of the Tertiary Older Volcanic Rocks of Victoria. *Proc. Roy. Soc. Vic.*, n.s., 51 (1), pp. 73-98.

———, 1940.—A Note on the Physiography of the Woori Yallock Basin. *Proc. Roy. Soc. Vic.*, n.s., 52 (2), pp. 336-341.

FERGUSON, W. H., 1931.—Recollections of Fossil Hunting. *Vic. Nat.*, vol. xlviii., No. 3, pp. 51-53.

GILL, E. D., 1940.—The Silurian Rocks of Melbourne and Lilydale. *Proc. Roy. Soc. Vic.*, n.s., 52 (2), pp. 249-261.

GREGORY, J. W., 1903.—The Geography of Victoria. Melbourne.

HILLS, E. S., 1934.—Some Fundamental Concepts in Victorian Physiography. *Proc. Roy. Soc. Vic.*, n.s., 47 (1), pp. 158-174.

———, 1935.—Section on Physiography in Outline of the Physiography and Geology of Victoria. A. and N.Z.A.A.Sc., Melbourne Meeting, pp. 78-89.

JUNNER, N. R., 1913.—General and Mining Geology of the Diamond Creek Area. *Proc. Roy. Soc. Vic.*, n.s., 25 (2), pp. 323-353.

JUTSON, J. T., 1911.—The Structure and General Geology of the Warrandyte Goldfield, etc. *Proc. Roy. Soc. Vic.*, n.s., 23 (2), pp. 516-554.

KEBLE, R. A., 1918.—The Significance of Lava Residuals in the Development of the Western Port and Port Phillip Drainage Systems. *Proc. Roy. Soc. Vic.*, n.s., 31 (1), pp. 129-165.

MORRIS, M., 1914.—On the Geology and Petrology of the District between Lilydale and Mount Dandenong. *Proc. Roy. Soc. Vic.*, n.s., 26 (2), pp. 331-366.

MURRAY, R. A. F., 1887.—Geology and Physical Geography of Victoria. Melbourne.

SELWYN, A. R. C., 1855-1856.—Report of the Geological Surveyor of the Geological Structure of the Colony of Victoria. *Votes and Proc. Legis. Council*, vol. 2, pt. 1.

STIRLING, V. R., 1899.—Geological Report on the Lilydale District. *Monthly Prog. Rep. Geol. Surv. Vic.*, No. 1, pp. 10-11.